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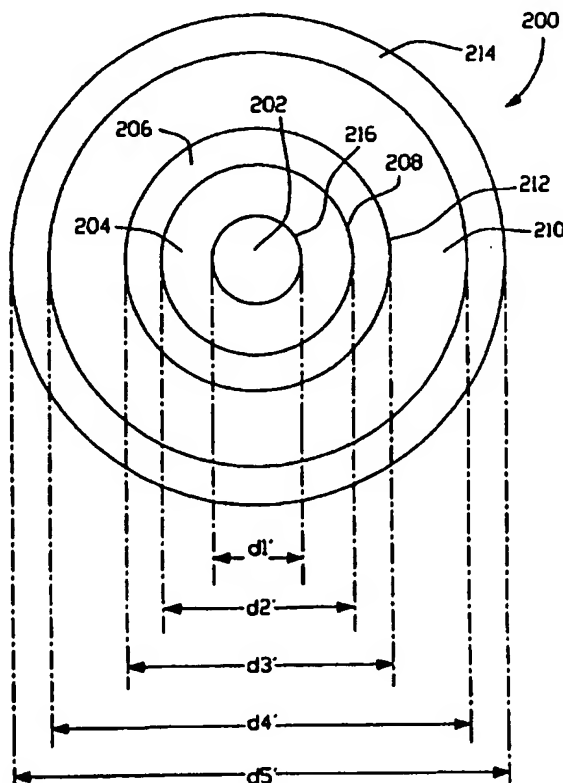
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**(54) Title:** MULTIFOCAL CONTACT LENS AND METHOD FOR PREPARING**(57) Abstract**

A multifocal contact lens (200) customized for a patient has, in accordance with the present invention, an anterior side with a power curve defined in part by (i) a central aspheric surface (202), (ii) an inner annular surface (204) contiguous with the central aspheric surface (202), (iii) a second annular surface (206) contiguous along a radially inner periphery (208) with the inner annular aspheric surface (204), and (iv) an outer annular surface (210) contiguous along a radially inner periphery (212) with the second annular aspheric surface (206). Each of the annular surfaces (204) and (210) is concentric or coaxial with the central aspheric surface (202). The central aspheric surface (202) corresponds to a distance vision correction zone. The inner annular surface (204) is an aspheric surface corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0. The second annular surface (206) corresponds to a near vision correction zone, and the outer annular surface (210) corresponds to a distant vision correction zone.



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**MULTIFOCAL CONTACT LENS AND METHOD FOR PREPARING****Background of the Invention**

This invention relates to a multifocal hydrophilic ("soft") and method of use in preparing and fitting a customized multifocal contact lens. This invention also relates to a multifocal contact lens produced using such a method.

Bifocal contact lenses are designed to correct or compensate for a condition of advancing age known as "presbyopia." In a presbyopic eye, the ability to focus at near distances, such as the normal reading distance, and in some cases at intermediate distances, is diminished. The loss of focusing capability is due to hardening of the eye's natural crystalline lens material.

Generally, multifocal contact lenses (usually either bifocal, trifocal or aspheric) are concentric or segmented in configuration. In a conventional bifocal contact lens of the concentric type, a first, centrally located, circular correction zone constitutes either distant or near vision correction, while a second annular correction zone surrounding the first zone provides the corresponding near or distance vision correction, respectively. In a conventional bifocal contact lens of the segmented or translating type, the lens is divided into two somewhat D-shaped zones. Usually the upper area is for distance vision correction, whereas the lower area is for near vision correction. Such conventional segmented contact lenses require some sort of movement of the lens relative to the eye to achieve acceptable visual acuity for both distant and near vision.

One accepted method of fitting contact lenses is based on taking so called K readings (which measure the center of the cornea) and fitting the center of the contact lens in a predetermined relationship to those readings. This, however, is not the only method of fitting contact lenses.

In all conventional bifocal fitting techniques, the bifocal or multifocal contact lenses is optimally designed to be particularly positioned on the cornea. However, it is very difficult in many cases, to position the lens to achieve the required fit. In general, the hardest part of fitting a lens is to position the lens at a desired location on the patient's cornea.

Precise fitting of a bifocal contact lens to the eye

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is crucial in so called simultaneous vision contact lenses where the brain receives both near and far vision input and selects between the near vision input and the far vision input, depending on the desired object(s) of perception.

As mentioned above, the segmented bifocal contact lenses translate to some extent on the eye. Such lenses cannot be locked onto the cornea. However, for good vision, some stability is necessary.

#### Objects of the Invention

An object of the present invention is to provide a multifocal contact lens.

Another, more particular, object of the present invention is to provide such a contact lens wherein the refractive power is defined by forming aspheric power curves on anterior and/or posterior surfaces of the lens.

Another particular object of the present invention is to provide such a multifocal contact lens which is made from a polymer material which provides at least about 10% by weight water after hydration.

Yet another object of the present invention is to provide such a lens which has at least one spheric or aspheric posterior surface, or a combination of spheric and aspheric surfaces.

These and other objects of the present invention may be gleaned from the drawings and detailed descriptions set forth herein.

#### Summary of the Invention

A multifocal contact lens customized for a patient has, in accordance with the present invention, an anterior side with a power curve defined in part by a (i) central aspheric surface, (ii) an inner annular surface contiguous with the central aspheric surface, (iii) a second annular surface contiguous along a radially inner periphery with the inner annular aspheric surface, and (iv) an outer annular surface contiguous along a radially inner periphery with the second annular aspheric surface. Each of the annular surfaces is concentric or coaxial with the central aspheric surface. The central aspheric surface corresponds to a distance vision correction zone. The inner annular surface is an aspheric sur-

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face corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0. The second annular surface corresponds to a near vision correction zone, and the outer annular surface corresponds to a distant vision correction zone.

According to other features of the present invention, the central aspheric surface has a diameter between approximately 1.5 mm and approximately 2.5 mm, the inner annular surface has an outer diameter between approximately 2.0 mm and approximately 3.5 mm, the second annular surface has an outer diameter between approximately 2.3 mm and approximately 4.0 mm, and the outer annular surface has an outer diameter between approximately 3.5 and approximately 8.0 mm. In one specific embodiment of the invention, the central aspheric surface has a diameter of approximately 2.2 mm, the inner annular surface has an outer diameter of approximately 2.8 mm, the second annular surface has an outer diameter of approximately 3.5 mm, and the outer annular surface has an outer diameter of approximately 8.0 mm.

According to a further feature of the present invention, the central aspheric surface has a standard eccentricity between approximately -0.6 and approximately -1.0. In the specific embodiment of the invention, the central aspheric surface has an eccentricity of approximately -0.8.

According to another feature of the present invention, the inner annular surface has a standard eccentricity between approximately -3.0 and approximately -5.0.

According to additional features of the present invention, the second annular surface and the outer annular surface are both spheric. However, either or both of the second annular surface and the outer annular surface may be aspheric.

The anterior side of the lens may have an annular lenticular area with an inner periphery contiguous with the outer annular surface and with an outer diameter between approximately 8.0 mm and approximately 14.5 mm.

In accordance with further features of the present invention, the central aspheric surface has a maximum change in power of approximately 1/2 diopter from the center radially

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outwardly to the peripheral edge, while the inner annular surface has a maximum change in refractive power of approximately three and one-half diopters as measured radially from an inner periphery of the inner annular surface to an outer periphery thereof.

It is contemplated that the multifocal contact lens has an aspheric cornea-fitting posterior surface, with an eccentricity magnitude ranging from 0.0 to about 1.0.

A multifocal contact lens in accordance with the present invention may be manufactured from hydrophilic or soft (hydrogel) polymeric materials i.e., polymeric materials which contain at least about 10% by weight water after hydration, such as disclosed in U.S. Patents Nos. 5,314,960 and 5,314,961, the disclosure of which is hereby incorporated by reference.

In accordance with a more general conceptualization of the present invention, a multifocal contact lens customized for a patient has an anterior side with a power curve defined in part by a (i) central aspheric surface, (ii) an inner annular surface contiguous with the central aspheric surface, (iii) a second annular surface contiguous along a radially inner periphery with the inner annular aspheric surface, and (iv) an outer annular surface contiguous along a radially inner periphery with the second annular aspheric surface. Each of the annular surfaces is concentric or coaxial with the central aspheric surface. The inner annular surface is an aspheric surface corresponding to a progressive add zone with a standard eccentricity having a magnitude between approximately 1.5 and approximately 5.0.

In a specific embodiment of the invention, the central aspheric surface corresponds to a distance vision correction zone, the progressive add zone corrects intermediate and near vision, the second annular surface corresponds to a near vision correction zone, and the outer annular surface corresponds to a distant vision correction zone. In addition, the standard eccentricity of the inner annular surface is between approximately -1.5 and approximately -5.0 and, more preferably, between -3.0 and -5.0.

In a similar bifocal contact lens in accordance with

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the present invention, the central aspheric surface corresponds to a near vision correction zone and has a standard eccentricity between approximately +1.5 and +5.0 and preferably between approximately +3.0 and +3.5, whereas the inner annular surface has a standard eccentricity between approximately +1.5 and approximately +3.5 and preferably about +2.5. The second annular correction surface has a standard eccentricity between approximately +0.3 and approximately +1.0 and preferably approximately 0.8. In such a lens, the central aspheric correction zone has a diameter between about 1.1 mm and about 2.2 mm, while the inner annular surface has an outer diameter between about 1.1 mm and about 2.5 mm. The second annular surface has an outer diameter between about 2.0 mm and about 8.0 mm. Usually, a lens with a central near vision correction zone in accordance with the present invention will have only three vision correction zones, although a fourth zone may be appropriate in some cases.

A customized multifocal contact lens in accordance with an even more general conceptualization of the present invention has an anterior side with a power curve defined in part by a central aspheric surface and an annular surface contiguous and coaxial or concentric with the central aspheric surface, the annular surface being an aspheric surface corresponding to a progressive add zone with a standard eccentricity having a magnitude between approximately 1.5 and approximately 5.0. Where the central aspheric surface corresponds to a distance vision correction zone, the annular surface is an aspheric surface corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0. In that case, the central aspheric surface has a diameter between about 1.5 mm and 2.8 mm, while the annular surface has an outer diameter between about 1.5 mm and 8.0 mm.

The present invention relies in part on a method for preparing a customized soft or hydrophilic multifocal contact lens wherein a standard diagnostic hydrophilic contact lens having a predetermined refractive power for distance vision is first placed on the patient's eye and allowed to seat itself in a natural position. The hydrophilic lens of the present

invention will generally seat itself in a substantially centered position (which term shall include a somewhat off-centered position).

In one step of the method, an over-refraction is performed using the diagnostic lens in its natural position on the patient's cornea to determine an aspheric power curve which may be applied to a first portion or area of a prescription multifocal contact lens to provide optimal distance vision for the patient. In another step, a further over-refraction is performed to determine a second aspheric curve to provide near vision for the patient. As discussed above, the distance vision area may be a central area of the lens, while the near vision area is an annular area concentric or coaxial with the central area and adjacent thereto. Alternatively, the central zone may be a near vision correction zone, while distance vision is corrected by an annular zone located concentrically or coaxially with respect to the central zone. In both cases, a further distance vision correction zone may be provided in a lenticular area of the lens. The refractive power of this additional zone may be defined in part by a spheric surface on the anterior side of the lens conforming to the prescription needs of the individual patient. In any event, the outer distance vision correction zone is effective to assist in the correction of distance vision under low levels of illumination, for example, during night driving.

The patient is fitted with a lens having the same posterior profile as the diagnostic lens and an anterior profile with two or more concentric or coaxial aspheric surfaces having different respective eccentricity values which are standard values selectable from a plurality of predetermined eccentricities. The anterior power curve will generally comprise at least two and may comprise as many as four aspheric curves, each having a different eccentricity value, to provide adequate vision for near, intermediate and far distances. In certain instances, such as in mature presbyopes, in order to accommodate near, intermediate and distance vision, the prescription lens preferably will comprise central, paracentral and peripheral aspheric curves, each having a different eccentricity value and a clinically determined power or



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spheric base curvature, on the anterior surface of the lens and a single posterior spheric or aspheric curve of predetermined eccentricity, or optionally and preferably, a spheric curve combined with an aspheric curve of predetermined eccentricity.

Upon placement of a diagnostic hydrophilic contact lens on the cornea of a patient's eye so that the fitting surface is in substantial alignment with the cornea, the diagnostic lens usually aligns itself with the cornea in a substantially centered position. In this position, where the diagnostic lens has two aspheric power curves and one spheric power curve, the patient may have adequate distance vision. With the appropriate diagnostic lens in place, the patient's near vision will be determined. Over-refraction of the lens for near vision will indicate a spheric or aspheric power curve to be cut on the anterior side of this lens. The lens which is produced from this process may be adequate to provide intermediate vision, in addition to near and distance vision.

Generally, a diagnostic lens used in a fitting method in accordance with the present invention will have a plurality of concentric or coaxial areas with respective predetermined power curves on the anterior side of the lens.

To accommodate a patient with a multifocal contact lens in accordance with the present invention, the maximum change in refractive power in a radially outward direction across any distance vision correction zone (plan view) should be no greater than approximately one diopter. Thus, the change in refractive power from the center of the lens to the boundary between a central distant-vision correction zone and a first annular correction zone (near vision) should be no greater than approximately one diopter and preferably no greater than one-half diopter. Similarly, the change in refractive power across the width of an annular distance vision correction zone generally should be no greater than approximately 1 diopter and preferably no greater than one-half diopter. It is to be noted, additionally, that the change in eccentricity from one correction zone to the next should be gradual, to reduce stress on the eye. Thus, in certain instances two aspheric curves may suffice to provide

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adequate multifocal vision and in other instances, one or more additional aspheric surfaces of varying eccentricity will be used to provide the gradual change between zones to accommodate the patient's vision.

A method for use in preparing a customized multifocal contact lens utilizes, in accordance with a relatively particular conceptualization of the present invention, a standard diagnostic contact lens having a concave cornea-fitting posterior surface, the diagnostic contact lens also having (i) a convex anterior surface with a central aspheric surface corresponding to a distant vision correction zone of a predetermined refractive power, (ii) an aspheric inner annular surface contiguous with the central aspheric surface and corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0, (v) a second annular surface contiguous along a radially inner periphery with the inner annular aspheric surface, and (vi) an outer annular surface contiguous along a radially inner periphery with the second annular aspheric surface. Each of the annular surfaces is concentric or coaxial with the central aspheric surface. The second annular surface corresponds to a near vision correction zone of predetermined refractive power, while the outer annular surface corresponds to a distant vision correction zone of predetermined refractive power. The method includes the steps of (a) placing the diagnostic contact lens on the cornea of a patient's eye so that the posterior surface is in substantial contact with the cornea, (b) allowing the diagnostic contact lens to align itself with the cornea in a natural position while the patient looks at an effectively distant object and (c) disposing a series of test lenses before the patient's eye, upon aligning of the diagnostic contact lens in the natural position, to determine a first aspheric power curve with which the central aspheric surface could be formed to provide optimal far vision for the patient under conditions of relatively high illumination and to further determine a power curve with which the outer annular surface could be formed to provide optimal distance vision under conditions of relatively low illumination. In another step, while the patient looks at an effectively

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near object, another series of test lenses is disposed before the patient's eye to determine a power curve with which the second annular surface could be formed to provide optimal near vision for the patient under conditions of average reading illumination.

The fitting or lens preparation method described above recognizes the difficulty of providing adequate multifocal hydrophilic contact lenses. However, instead of struggling to achieve absolute corneal centering, as some fitting techniques attempt, the instant method obviates the difficulty by assuming that the greatest majority of fitted multifocal lenses will be centered or slightly off-centered on the cornea. In a method in accordance with the present invention, the diagnostic lens positions itself in its natural position, which, in hydrophilic lenses, is centered or substantially centered (slightly off-center). Because the finished lens has the same back surface design as the diagnostic lens, there is no need to further position either the diagnostic lens or the finished product, which should naturally position the same way as the diagnostic lens.

The present invention recognizes that each cornea is different and, instead of molding or fitting a lens precisely to center on the eye, the instant contact lens preparation technique selects among a fixed number of prescribed standard fitting or diagnostic lenses and then modifies only the anterior surface in order to achieve an optimal multifocal vision. This method can change differential powers of the two or more concentric or coaxial anterior aspheric zones without appreciably affecting the fit.

Because the anterior surface of the lens manufactured in accordance with the present invention contains multiple concentric or coaxial aspheric surfaces, the lens has a multiplicity of refractive powers. For a centrally located aspheric surface which corrects for distance vision, these powers are least plus or most minus at the vertex and progressively become more plus or less minus from the vertex radially to the periphery of the central zone. For a central near vision correction zone, these powers are most plus or least minus at the vertex and progressively become less plus or more

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minus from the vertex radially to the periphery of the central zone.

Whenever one refracts over such a lens on the eye using spheric ophthalmic lenses, the patient subjectively chooses that ophthalmic lens power combined with the multiplicity of lens powers in the aspheric central zone of the contact lens which provides the best acuity of vision at both far distance and near distance. There is a cortical interpretation of the independent images to determine the best acceptable summation of images.

The present invention may be used with all standard contact lens materials, i.e. rigid (gas permeable or PMMA), but is preferably used with soft (hydrogel) polymeric materials i.e., polymeric materials which contain at least about 10% by weight water after hydration, such as disclosed in U.S. Patents Nos. 5,314,960 and 5,314,961.

#### Brief Description of the Drawing

Fig. 1 is a schematic front elevational view of a diagnostic contact lens for use in fitting a patient with a simultaneous type multifocal contact lens in accordance with the present invention.

Fig. 2 is a cross-sectional view taken along line II-II in Fig. 1, showing in phantom lines an ophthalmic lens positioned in front of the diagnostic lens for fitting purposes.

Fig. 3 is a partial cross-sectional view, on an enlarged scale, of the ophthalmic lens of Figs. 1 and 2, showing an edge bevel.

Fig. 4 is a schematic cross-sectional view of a multifocal contact lens.

Fig. 5 is a schematic cross-sectional view of a multifocal contact lens in accordance with the present invention.

Fig. 6 is a schematic front elevational view, on an enlarged scale, of another multifocal contact lens.

Fig. 7 is a schematic front elevational view, on an enlarged scale, of a multifocal contact lens in accordance with the present invention.

#### Detailed Description

In preparing a customized multifocal contact lens, a

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standard diagnostic contact lens 10 as illustrated in Figs. 1 and 2 is first placed on the patient's eye and allowed to seat itself in a natural, substantially centered, position. The anterior side of the lens has a plurality of concentric or coaxial aspheric surfaces essentially alignable with the cornea of the patient's eye. The posterior side of the lens is formed with a spheric or aspheric surface which is adapted to fit the lens to the cornea of the patient. If, upon placement on the patient's cornea, the diagnostic lens does not produce adequate distance vision, a first over-refraction is performed to determine a first aspheric power curve for a central anterior zone of the lens. This central power curve is responsible for correcting distance vision and is provided by modifying a central portion of the anterior surface of a finished prescription lens having the same posterior surface as the diagnostic lens 10. An additional over-refraction is then performed to determine a second power curve for an annular anterior area or zone of the lens to provide adequate near distance correction. The second power curve is formed by modifying an annular portion of the anterior surface of the finished prescription lens. A third, spheric, power curve is provided in an annular, outer or lenticular area of the finished lens to assist in the correction of distance vision under low levels of illumination, for example, during night driving. Generally, an anterior surface of the lens will have only two anterior annular aspheric power curves. In other cases, the anterior surface may have more than two aspheric power curves.

As described in detail hereinafter, if the above discussed procedure fails to provide satisfactory near and distance vision, a different diagnostic lens may be used to determine aspheric power curves where the central zone on the anterior side of the lens is a near vision correction zone, while a first annular area is a distance vision correction zone.

As shown in Fig. 1 and 2, a first diagnostic lens 10 tried on the patient has a concave cornea-fitting posterior surface 14. Surface 14 may be spheric or preferably, aspheric with a predetermined eccentricity ranging from 0.0 to about

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1.0. Lens 10 also has, on an anterior side, a standard annular spheric or aspheric surface 12 and a standard central aspheric surface 18, each surface having a predetermined eccentricity. Generally, surfaces 12 and 18 have different eccentricities. However, it is also possible for them to have the same eccentricity. In addition, this first diagnostic lens may have, at an annular periphery of lens 10, an edge radius 22 (Figs. 2 and 3) which is turned to the side of a center line CN. Accordingly, by virtue of the use of an aspheric surface, surface 14 of the lens is curved down to fit against the cornea of the patient's eye. It is noted that the edge radius is an optional feature of the lens.

In fitting a patient with a multifocal contact lens, diagnostic lens 10 is placed on the cornea of the patient's eye so that cornea-fitting posterior surface 14 is in substantial contact with the cornea. Lens 10 is allowed to align itself with the cornea in a substantially centered position. Upon an alignment of diagnostic contact lens 10 in the substantially centered position, a series of conventional spheric ophthalmic test lenses 26 (Fig. 2) are disposed before the lens 10 on the patient's eye to determine a power curve 28 (Fig. 2) with which anterior surface 18 of a central lens portion 16 can be formed to provide optimal distance vision for the patient. A subsequent over-refraction is performed to determine a spheric or aspheric power curve with which annular surface 12 of the lens may be formed to provide optimal near vision for the patient.

To optimize the fitting of lens 10 to any particular patient's cornea, lens 10 is first selected from a kit of standard diagnostic contact lenses each having concave cornea-fitting posterior surface 14 and central lens portion 16 with predetermined annular spheric or aspheric surface 12 and predetermined central aspheric surface 18. Surface 18 has a predetermined standard eccentricity between approximately 0.40 and approximately 1.80 and preferably between approximately 0.6 and 1.0.

Most of the lenses 10 in the kit have cornea-fitting posterior surfaces 14 which are spheric or aspheric with eccentricities between 0.0 and about 1.0.

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The patient is fitted first with a diagnostic or fitting contact lens 10 having a posterior surface 14 which substantially matches the cornea of the patient about the iris. Of course, precise matching is undesirable, because space is required for tear flow, etc.

Two or more different standard diagnostic contact lenses 10 may be tested sequentially on the cornea of the patient to determine which has the most appropriate cornea-fitting surface 14 and anterior surfaces 12 and 18. However, a suitable diagnostic lens may be preselected inasmuch as appropriateness of surfaces 12 and 18 depends in large part on the needs of the particular patient, for example, on whether the lens is to be used primarily for reading, primarily in social situations, or primarily for distance vision correction.

Upon the selection of a diagnostic lens 10 which has a suitable cornea-fitting surface 14 and which provides the best distance vision, a first over-refraction is performed, if necessary, to determine an aspheric power curve 28 with which the central area 18 of the lens is formed to optimize the correction for distance vision. The same over-refraction procedure may be used to determine a spheric power curve with which an annular lenticular or outer area of the lens may be formed to provide further distance vision correction.

A second over-refraction procedure is subsequently performed to determine a power curve for modifying annular spheric or aspheric surface 12 of central portion 16 for the final lens to provide adequate near vision. This over-refraction procedure is performed with the patient focusing on a near object. Upon the determination of an appropriate near vision power curve, the appropriate spheric or aspheric curve is formed on the anterior side of a prescription lens having the same posterior configuration as the diagnostic lens. This lens, once manufactured to the prescription established by the diagnostic procedure should provide adequate near, distance and intermediate vision. However, as discussed below with reference to Fig. 7, intermediate vision may be corrected by a paracentral aspheric progressive-add surface on the anterior side of the lens.

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Generally, as illustrated in Fig. 5, a multifocal contact lens 110 customized for a patient pursuant to the above-described fitting methodology will have an anterior side 112 with a power curve defined in part by a central aspheric surface 114 and at least one annular aspheric surface 116 concentric or coaxial therewith. Where central aspheric surface 114 corresponds to a distance vision correction zone, it will have a standard eccentricity value between about -0.6 and about -1.2 and, more preferably, between about -0.75 and about -0.85. In lens 110, annular aspheric surface 116 corresponds to a progressive-add correction zone and has a standard eccentricity value between about -1.35 and about -2.5. The negative eccentricities mean that the deviations from spheric result in a radius of curvature which is smaller than, or reduced with respect to, a spheric radius. Conversely, where eccentricities are positive, the deviations from spheric result in a radius of curvature which is greater than than, or increased with respect to, a spheric radius. Negative eccentricities thus correspond to a steepening of the power curve while positive eccentricities correspond to a flattening of the power curve.

As further illustrated in Fig. 5, anterior side 112 of lens 110 also has an annular lenticular area 118 with a spheric power surface providing an additional correction for distance vision. The power curve for lenticular area 118 is determined during the same over-refraction procedure used to determine the power curve for central aspheric surface 114.

Patient-customized lens 110 has a cornea-fitting posterior surface 120 which is either spheric or aspheric with an eccentricity value ranging from 0.0 to about 1.0. As discussed above, this posterior surface 120 has essentially the same form or profile as posterior surface 14 of the diagnostic lens 10 used to determine the power curves for surfaces 114, 116, and 118.

Preferably, central aspheric surface 114 has a diameter  $d_1$  between approximately 1.6 mm and approximately 2.3 mm, while annular aspheric surface 116 has a diameter  $d_2$  between approximately 2.9 mm and 3.6 mm. For example, central aspheric surface 114 may have a standard diameter of



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approximately 2.2 mm, while annular aspheric surface 116 has a standard diameter of approximately 3.0 mm or 3.5 mm. In some cases, the diameter of central aspheric surface 114 will be reduced to approximately 1.9 mm, for purposes of providing adequate vision enhancement.

Lens 110 may be manufactured from a hydrophilic polymer such as those disclosed in U.S. Patents Nos. 5,314,960 and 5,314,961, the disclosures of which are hereby incorporated by reference.

As discussed above, in some cases, depending on the patient's reaction to the over-refraction procedure, central aspheric surface 114 of customized multifocal contact lens 110 corresponds to a near vision correction zone and has a standard eccentricity value between about 1.35 and about 2.5. Concomitantly, annular aspheric surface 116 corresponds to a distance vision correction zone having a standard eccentricity value between about 0.6 and about 1.2 and, preferably, between about 0.8 and about 0.9. In this embodiment also, annular lenticular area 112 is provided with a spheric power surface providing a distance vision correction.

It is to be noted that one eye of a patient may be provided with a lens 110 where central aspheric surface 114 is a distance vision correction zone, while the other eye of the patient is provided with a lens 110 where central aspheric surface 114 is a near vision correction zone. This is a kind of modified monovision, based on the same principles as those underlying the contact lens combinations disclosed in U.S. Patent No. 5,002,382 or 5,024,517. Alternatively, where the central aspheric surfaces 114 of both contact lenses 110 correct distance vision and have standard eccentricity values between about -0.6 and about -1.2 and the annular aspheric surfaces correspond to progressive-add-type correction zones with standard eccentricity values between about -1.35 and about -2.5, the central aspheric surface of the lens for a dominant eye of the patient is larger in diameter than the central aspheric surface of the lens for a nondominant eye of the patient. In this case, the diameter of annular aspheric surface 114 of the dominant lens is substantially equal to the diameter of the annular aspheric surface of the nondominant

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lens. Specifically, the diameter of the central aspheric surface of the dominant lens is about 2.2 mm and the diameter of the central aspheric surface of the nondominant lens is about 1.9 mm, while the diameter of the annular aspheric surface of either lens is between about 3.0 mm and about 3.5 mm.

As illustrated in Fig. 6, another customized multifocal contact lens 122 has an anterior side 124 with a power curve defined in part by a central aspheric surface 126 and two annular aspheric surfaces 128 and 130 concentric or coaxial therewith. Central aspheric surface 126 corresponds to an intermediate vision correction zone and has a standard eccentricity value between about 1.2 and about 1.7, while annular aspheric surface 128 corresponds to a distance vision correction zone with a standard eccentricity value between about 0.6 and about 1.2. Annular aspheric surface or lenticular area 130 corresponds to a near vision correction zone with a spheric power curve. Central aspheric surface 126 has a diameter  $d_3$  between approximately 1.5 mm and 2.0 mm, while annular aspheric surface 128 has a diameter  $d_4$  between approximately 3.0 mm and 3.7 mm. Again, lens 122 has a posterior profile or surface (not shown) which is the same as that of the diagnostic lens ultimately selected for determination of the powers of aspheric surfaces 126, 128, 130 during the over-refraction process. The eccentricity of the posterior surface, as well as the eccentricities of surfaces 126, 128, and 130, are standard values selectable from a plurality of predetermined eccentricities. Lens 122 is particularly well suited for mature presbyopes, in order to accommodate near, intermediate and distance vision.

To provide adequate vision correction without confusing visual perception of the patient, the maximum change in refractive power in a radially outward direction across any single distance vision correction zone (plan view) 114, 116, 118 (Fig. 5) or 128 (Fig. 6) should be no greater than approximately one diopter or, more preferably, one-half diopter. Thus, the change in refractive power from the center of a "center distance" lens 110 to the boundary between central distant-vision correction zone 114 and annular near vision correction zone 116 should be no greater than approximately

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one diopter or, more preferably, one-half diopter. Similarly, the change in refractive power across the width of annular distance vision correction zone 116 of a "center near" lens generally should be no greater than approximately 1 diopter or, more preferably, one-half diopter. In addition, the change in eccentricity from one correction zone to the next should be gradual, to reduce stress on the eye. Thus, in certain instances two aspheric curves may suffice to provide adequate multifocal vision and in other instances, one or more additional aspheric surfaces of varying eccentricity will be used to provide the gradual change between zones to accommodate the patient's vision.

In order to secure acceptable distance vision and near vision in a multi-focal contact lens pursuant to the above-described procedure, particularly where there is a significant difference in "add" between the prescription or power curve for distance vision and the prescription or power curve for near vision, the lens may be formed to float or translate slightly on the cornea to an extent greater than normal. Thus, in the case of a contact lens having two anterior aspheric surfaces, a steeper part of the power curve may be shifted over the pupil for near vision. In the case of a lens with a third, paracentral anterior aspheric surface, the slight translation of the lens may serve to shift the lenticular area more squarely over the pupil for near vision.

As depicted in Fig. 7, a multifocal contact lens 200 customized for a patient has an anterior side with a power curve defined in part by a central aspheric surface 202, an inner annular surface 204 contiguous with central aspheric surface 202, a second annular surface 206 contiguous along a radially inner periphery 208 with inner annular aspheric surface 204, and an outer annular surface 210 contiguous along a radially inner periphery 212 with second annular aspheric surface 206. Each of the annular surfaces 204 and 210 is concentric or coaxial with central aspheric surface 202. Central aspheric surface 202 corresponds to a distant vision correction zone. Inner annular surface 204 is an aspheric surface corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0

and, more preferably between approximately -3.0 and approximately -5.0. Second annular surface 206 corresponds to a near vision correction zone, while outer annular surface 210 corresponds to a distant vision correction zone. Annular surfaces 206 and 210 may be spheric or aspheric.

Central aspheric surface 202 has a diameter  $d1'$  between approximately 1.5 mm and approximately 2.5 mm, while inner annular surface 204 has an outer diameter  $d2'$  between approximately 2.0 mm and approximately 3.5 mm. Second annular surface 206 has an outer diameter  $d3'$  between approximately 2.3 mm and approximately 4.0 mm, and outer annular surface 210 has an outer diameter  $d4'$  between approximately 3.5 and approximately 8.0 mm. An annular lenticular area 214 of lens 200 has no power curve and has an outer diameter  $d5'$  between approximately 8.0 mm and approximately 14.5 mm. Central aspheric surface 202 has a standard eccentricity between approximately -0.6 and approximately -1.0 and more preferably between about -0.75 and about -0.85.

In one specific embodiment of the invention, diameters  $d1'$  through  $d5'$  are approximately 2.2 mm, approximately 2.8 mm, approximately 3.5 mm, approximately 8.0 mm, and approximately 14.5 mm, respectively. Central aspheric surface 202 has an eccentricity of approximately -0.8, while inner annular surface 204 has a standard eccentricity of approximately -5.0.

Central aspheric surface 202 has a maximum change in power of approximately 1/2 diopter from the center radially outwardly to its peripheral edge 216, while inner annular, progressive-add surface 204 has a maximum change in refractive power of approximately three and one-half diopters as measured radially from edge 216 to periphery 208.

Multifocal contact lens 200 has an aspheric cornea-fitting posterior surface (not designated), with an eccentricity magnitude ranging from 0.0 to about 1.0.

Multifocal contact lens 200 may be manufactured from hydrophilic or soft (hydrogel) polymeric materials i.e., polymeric materials which contain at least about 10% by weight water after hydration, such as disclosed in U.S. Patents Nos. 5,314,960 and 5,314,961, the disclosure of which is hereby

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incorporated by reference.

Central aspheric surface 202 corrects distance vision particularly under conditions of high illumination, while outer annular surface 210 corrects distance vision particularly under conditions of low illumination such as night driving. Progressive-add surface 204 corrects vision for intermediate distances.

Lens 200 is fitted as described above, using a diagnostic or test lens with the same posterior surface as lens 200 and an anterior side with a central aspheric surface of a predetermined standard eccentricity and power and at least one annular spheric or aspheric surface of a predetermined standard eccentricity and power. Power curves for central aspheric surface 202 and outer annular surface 210 are determined, as discussed above, during a first over-refraction procedure wherein a diagnostic or test lens is placed on the cornea of the patient's eye. A power curve for second annular surface 206 is determined during a second over-refraction procedure. The power curves for central aspheric surface 202 and outer annular surface 210 may be determined under high illumination and low illumination levels, respectively. The power curve for paracentral or progressive-add surface 204 is determined by the preselected standard eccentricity of that intermediate zone and by the results of the first (distant vision) over-refraction procedure. Any progressive add zone (eccentricity of high magnitude) will provide a continuous range of powers to the retina and the brain of the patient. The patient's visual cortex selects from among that continuous range of powers or adds to obtain a focused sight.

It is to be noted that in some circumstances, the outer two annular surfaces or correction zones 206 and 210 may be omitted in a prescription lens. Such a simplified lens has only a central aspheric surface 202 and an annular progressive add surface or zone. The central aspheric surface has a diameter between about 1.5 mm and about 2.8 mm, while the annular progressive add zone has an outer diameter between about 1.5 mm and about 8.0 mm. The progressive add zone has a standard eccentricity having a magnitude between approximately 1.5 and approximately 5.0. Where the central aspheric surface

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corresponds to a distance vision correction zone, the annular surface is an aspheric surface corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0.

In another modification of the contact lens of Fig. 7, only the outer annular zone 210 is omitted.

In an alternative lens having the general structure set forth above with respect to Fig. 7, the central aspheric surface corresponds to a near vision correction zone with a standard eccentricity between approximately +1.5 and approximately +5.0 and preferably between approximately +3.0 and approximately +3.5, whereas the inner annular surface has a standard eccentricity between approximately +1.5 and approximately +3.5 and preferably about +2.5. The second annular correction surface has a standard eccentricity between approximately +0.3 and approximately +1.0 and preferably approximately 0.8. In such a lens, the central aspheric correction zone has a diameter between about 1.1 mm and about 2.2 mm, while the inner annular surface has an outer diameter between about 1.1 mm and about 2.5 mm. The second annular surface has an outer diameter between about 2.0 mm and 8.0 mm. Usually, a lens with a central near vision correction zone in accordance with the present invention will have only three vision correction zones, although a fourth zone may be appropriate in some cases.

As illustrated in Figs. 1 and 2, diagnostic lens 10 has at least one transition junction 24 where the anterior annular aspheric surface 12 meets central aspheric surface 18. At transition junction 24, the radii of curvature of surfaces 12 and 18 are approximately equal. However, the eccentricities of those aspheric anterior surfaces remain different.

An eccentricity between 0.0 and about 1.0 for cornea-fitting posterior surface 14 of a diagnostic hydrophilic lens or a finished prescription lens is in accordance with the aspheric topographical characteristics of the human cornea. With such an eccentricity, cornea-fitting posterior surface 14 is fitted relatively tightly to the patient's eye, so that the lens, which may move slightly with

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eye and eyelid movement, does not move significantly with movement of the upper eyelid.

Upon the completion of the over-refraction process, the patient is fitted with a prescription lens 110, 122, 200 (generally, from a lens production laboratory) which is substantially identical to the finally used diagnostic lens 10. The prescription lens may have two anterior aspheric surfaces (Fig. 5 or 7) or three (or more) anterior aspheric surfaces. The anterior surface of the selected lens blank is machined or, more specifically, lathed to produce the appropriate anterior aspheric surfaces 126, 128, 130 (Fig. 5) or 202, 204, 206, 210 (Fig. 7). Alternatively, either the posterior or anterior surface of the lens or the entire lens, including posterior and anterior surfaces, may be molded.

In most cases, over-refraction of diagnostic lens 10 will provide adequate vision for near, intermediate and far distances. In such a case, a lens having a posterior surface with a single spheric or aspheric curve 14 may be used with good success. In certain instances, it may be advantageous to provide a second aspheric surface (not shown) on the periphery of the cornea-fitting posterior surface 14, each of the aspheric posterior surfaces ranging in eccentricity from about 0.0 to about 1.0.

By incorporating the features of the contact lenses, it is now possible to avoid having to fit the patient in a rigid set or established position, thus obviating one of the more difficult problems of bifocal/multifocal contact lens fitting. Instead, the fit or position of the lens is first established naturally and thereafter, the visual characteristics of the lens are designed into the finished lens.

Generally, as is well known in the art, if the anterior power curve is decreased by 12 lines for each diopter, the add is 1.0. A decrease of 6 lines for each 1/2 diopter results in an add of 0.5, while a decrease of 24 lines for each 2 diopters results in an add of 2.0. Similarly, a decrease of 48 lines for each 4 diopters results in an add of 4.0. This rule of thumb is helping in guiding the practitioner to design a lens which can accommodate varying powers of the lens in predetermined distances for maximum fit and

visual effectiveness.

Fig. 4 shows a special multifocal hydrophilic contact lens 50 with an optional enhanced intermediate vision correction. As illustrated in Fig. 4, a multifocal hydrophilic contact lens 50 has an anterior surface or side 52 with three concentric or coaxial aspheric surfaces 54, 56, and 58 each formed with a respective power curve having a standard eccentricity value between about 0.4 and about 2.5. The eccentricity values differ from one another by at least about 0.2 and by no more than about 0.8. Lens 50 has a concave cornea-fitting posterior surface 62 which includes at least one aspheric surface having an eccentricity value between about 0.0 and about 1.0.

Hydrophilic multifocal soft lens 50 may include one or more spheric or aspheric posterior surfaces, but preferably, lens 50 has one aspheric surface 62 ranging in eccentricity from about 0.0 to about 1.0. In certain embodiments of a contact lens, the posterior cornea-fitting surface of the contact lens may have two annular aspheric surfaces, each of which has an eccentricity value ranging from about 0.0 and about 1.0.

Central aspheric surface or power curve 54 provides distance vision and has an eccentricity value with a smaller magnitude than the magnitude of the eccentricity value of para-central aspheric surface or power curve 56 which provides intermediate vision. The eccentricity of para-central aspheric surface or power curve 56 in turn has a magnitude which is smaller than the magnitude of the eccentricity of peripheral aspheric surface or power curve 58, which provides a correction for near vision. Preferably, the eccentricity value of central aspheric power curve 54 is between about -0.4 and about -0.8, the eccentricity value of para-central aspheric surface or power curve 56 is between about -0.6 and about -0.8, and the eccentricity value of peripheral aspheric surface or power curve 58 is between about -0.8 and about -1.2.

Aspheric surfaces or power curves 54, 56 and 58 are determined in a fitting method utilizing a diagnostic lens having the same posterior surface 62 as lens 50 and an



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anterior surface 64 having a predetermined standard refractive power. That refractive power is for distance vision. Alternatively, the diagnostic lens may have a plurality of concentric or coaxial areas with respective predetermined standard refractive powers, e.g., for distance vision and near vision, respectively. The diagnostic lens is selected from a kit of diagnostic lenses with different posterior surfaces 62 and different overall dimensions. The diagnostic lens is selected to conform to the particular shape and dimensions of a patient's cornea.

The diagnostic contact lens is placed on the cornea of a patient's eye so that posterior cornea-fitting surface 62 is in substantial contact with the cornea. The diagnostic contact lens is allowed to align itself with the cornea in a substantially centered position while the patient looks at an effectively distant object. Upon aligning of the diagnostic contact lens in the substantially centered position, a series of test lenses is disposed before the patient's eye in a first over-refraction procedure to determine central aspheric surface or power curve 54 for providing optimal distance vision for the patient. In another over-refraction step, while the patient looks at an effectively near object, another series of test lenses is disposed before the patient's eye to determine aspheric surface or power curve 58 for providing optimal near vision for the patient. In yet another over-refraction step, while the patient looks at an intermediately distanced object, a further series of test lenses is disposed before the patient's eye to determine aspheric surface or power curve 56 for providing optimal intermediate distance vision for the patient.

Anterior aspheric surfaces or power curves 54, 56, and 58 are located in a central correction zone 66, an intermediate annular correction zone 68, and a peripheral annular correction zone 70, respectively. Aspheric surfaces or power curves 54, 56, and 58 are concentric or coaxial with a lens axis 72. It is to be noted that the eccentricity values of surfaces or power curves 54, 56, and 58 differ from one another by no more than about 0.8 in order to provide a smooth transition from one correction zone 66, 68, or 70 to another.

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A hydrophilic multifocal contact lens as depicted in Fig. 4 may have only a central correction zone 66 and a peripheral correction zone 70 with associated aspheric surfaces or power curves 54 and 58 for correcting distance vision and near vision, respectively. Alternatively, four aspheric surfaces or power curves may be provided, all ranging in eccentricity from about 0.4 to about 1.8, preferably from about 0.6 to about 1.0, each of the aspheric surfaces differing in eccentricity value within the range of about 0.2 to about 0.8.

It is to be noted that the change in eccentricity from aspheric surface or power curve 54 to aspheric surface or power curve 56, as well as the change in eccentricity from aspheric surface or power curve 56 to aspheric surface or power curve 58, should be gradual, to reduce stress on the eye.

Although the invention has been described in terms of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or exceeding the scope of the claimed invention. Accordingly, it is to be understood that the drawings and descriptions herein are proffered by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

## CLAIMS:

1. A multifocal contact lens customized for a patient, having an anterior side with a power curve defined in part by a (i) central aspheric surface, (ii) an inner annular surface contiguous with said central aspheric surface, (iii) a second annular surface contiguous along a radially inner periphery with said inner annular aspheric surface, and (iv) an outer annular surface contiguous along a radially inner periphery with said second annular aspheric surface, each of the annular surfaces being concentric or coaxial with said central aspheric surface, said central aspheric surface corresponding to a distance vision correction zone, said inner annular surface being an aspheric surface corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0, said second annular surface corresponding to a near vision correction zone, and said outer annular surface corresponding to a distant vision correction zone.

2. The lens defined in claim 1 wherein said central aspheric surface has a diameter between approximately 1.5 mm and approximately 2.5 mm, said inner annular surface has an outer diameter between approximately 2.0 mm and approximately 3.5 mm, said second annular surface has an outer diameter between approximately 2.3 mm and approximately 4.0 mm, and said outer annular surface has an outer diameter between approximately 3.5 and approximately 8.0 mm.

3. The lens defined in claim 2 wherein said central aspheric surface has a diameter of approximately 2.2 mm, said inner annular surface has an outer diameter of approximately 2.8 mm, said second annular surface has an outer diameter of approximately 3.5 mm, and said outer annular surface has an outer diameter of approximately 8.0 mm.

4. The lens defined in claim 3 wherein said central aspheric surface has a standard eccentricity between approximately -0.6 and approximately -1.0.

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5. The lens defined in claim 4 wherein said central aspheric surface has an eccentricity of approximately -0.8.

6. The lens defined in claim 5 wherein said inner annular surface has a standard eccentricity between approximately -3.0 and approximately -5.0.

7. The lens defined in claim 6 wherein said second annular surface and said outer annular surface are both spheric.

8. The lens defined in claim 7 wherein said anterior side has an annular lenticular area with an inner periphery contiguous with said outer annular surface and with an outer diameter between approximately 8.0 mm and approximately 14.5 mm.

9. The lens defined in claim 8 wherein said central aspheric surface has a center and a substantially circular peripheral edge, said central aspheric surface having a maximum change in power of approximately 1/2 diopter from said center radially outwardly to said peripheral edge.

10. The lens defined in claim 9, further comprising an aspheric cornea-fitting posterior surface.

11. The lens defined in claim 10 wherein said posterior surface has an eccentricity magnitude ranging from 0.0 to about 1.0.

12. The lens defined in claim 11 manufactured from a hydrophilic polymer.

13. The lens defined in claim 1 wherein said central aspheric surface has a standard eccentricity between approximately -0.6 and approximately -1.0 and said inner annular surface has a standard eccentricity between approximately -3.0 and approximately -5.0.

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14. The lens defined in claim 13 wherein said central aspheric surface has an eccentricity of approximately - 0.8.

15. The lens defined in claim 1 wherein said anterior side has an annular lenticular area with an inner periphery contiguous with said outer annular surface.

16. The lens defined in claim 1 wherein said second annular surface said outer annular surface are both spheric.

17. The lens defined in claim 1 wherein said central aspheric surface has a center and a substantially circular peripheral edge, said central aspheric surface having a maximum change in power of approximately 1/2 diopter from said center radially outwardly to said peripheral edge.

18. The lens defined in claim 1, further comprising an aspheric cornea-fitting posterior surface having an eccentricity magnitude ranging from 0.0 to about 1.0.

19. The lens defined in claim 1 manufactured from a hydrophilic polymer.

20. The lens defined in claim 1 wherein said inner annular surface has a maximum change in refractive power of approximately three and one-half diopters as measured radially from an inner periphery of said inner annular surface to an outer periphery thereof.

21. A multifocal contact lens customized for a patient, having an anterior side with a power curve defined in part by a (i) central aspheric surface, (ii) an inner annular surface contiguous with said central aspheric surface, (iii) a second annular surface contiguous along a radially inner periphery with said inner annular aspheric surface, and (iv) an outer annular surface contiguous along a radially inner periphery with said second annular aspheric surface, each of

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the annular surfaces being concentric or coaxial with said central aspheric surface, said inner annular surface being an aspheric surface corresponding to a progressive add zone with a standard eccentricity having a magnitude between approximately 1.5 and approximately 5.0.

22. The lens defined in claim 21 wherein said central aspheric surface corresponds to a distance vision correction zone, said second annular surface corresponds to a near vision correction zone, and said outer annular surface corresponds to a distant vision correction zone, the standard eccentricity of said inner annular surface being between approximately -1.5 and approximately -5.0.

23. The lens defined in claim 22 wherein said inner annular surface has a standard eccentricity between approximately -3.0 and approximately -5.0.

24. The lens defined in claim 21 wherein said central aspheric surface has a standard eccentricity with a magnitude between approximately 0.6 and approximately 1.0.

25. The lens defined in claim 24 wherein said central aspheric surface corresponds to a distant vision correction zone and has a standard eccentricity between approximately -0.6 and approximately -1.0.

26. The lens defined in claim 21 wherein said anterior side has an annular lenticular area with an inner periphery contiguous with said outer annular surface.

27. A multifocal contact lens customized for a patient, having an anterior side with a power curve defined in part by a central aspheric surface and an annular surface contiguous and coaxial or concentric with said central aspheric surface, said annular surface being an aspheric surface corresponding to a progressive add zone with a standard eccentricity having a magnitude between approximately 1.5 and approximately 5.0.

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28. The lens defined in claim 27 wherein said central aspheric surface corresponds to a distance vision correction zone, said annular surface being an aspheric surface corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0.

29. The lens defined in claim 28 wherein said central aspheric surface has a diameter between about 1.5 mm and 2.8 mm, said annular surface having an outer diameter between about 1.5 mm and 8.0 mm.

30. The lens defined in claim 28 wherein said annular surface is an inner annular surface on said anterior side, said anterior side also having a second annular surface contiguous along a radially inner periphery with said inner annular surface, said second annular surface corresponding to a near vision correction zone.

31. The lens defined in claim 30 said anterior side also having an outer annular surface contiguous along a radially inner periphery with said second annular surface, said outer annular surface corresponding to a distant vision correction zone.

32. A multifocal contact lens customized for a patient, having an anterior side with a power curve defined in part by a (i) central aspheric surface, (ii) an inner annular surface contiguous with said central aspheric surface, and (iii) a second annular surface contiguous along a radially inner periphery with said inner annular aspheric surface, each of the annular surfaces being concentric or coaxial with said central aspheric surface, said central aspheric surface corresponding to a near vision correction zone with a standard eccentricity between approximately +1.5 and approximately +5.0.

33. The lens defined in claim 32 wherein said inner

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annular surface is an aspheric surface with a standard eccentricity between approximately +1.5 and approximately +3.5, said second annular surface being an aspheric surface with a standard eccentricity between approximately +0.3 and approximately +1.0.

34. The lens defined in claim 33 wherein said central aspheric surface has a standard eccentricity between approximately +3.0 and +5.0, said inner annular surface has a standard eccentricity of approximately 2.5, and said second annular surface has a standard eccentricity of approximately +0.8.

35. The lens defined in claim 32 wherein said central aspheric surface has a diameter between about 1.1 mm and about 2.2 mm, said inner annular surface has an outer diameter between about 1.1 mm and about 2.5 mm, and said second annular surface has an outer diameter between about 2.0 mm and about 8.0 mm.

36. A method for use in preparing a customized multifocal contact lens, comprising the steps of:

providing a standard diagnostic contact lens having a concave cornea-fitting posterior surface, said diagnostic contact lens also having (i) a convex anterior surface with a central aspheric surface corresponding to a distant vision correction zone of a predetermined refractive power, (ii) an aspheric inner annular surface contiguous with said central aspheric surface and corresponding to a progressive add zone with a standard eccentricity between approximately -1.5 and approximately -5.0, (iv) a second annular surface contiguous along a radially inner periphery with said inner annular aspheric surface, and (v) an outer annular surface contiguous along a radially inner periphery with said second annular aspheric surface, each of the annular surfaces being concentric or coaxial with said central aspheric surface, said second annular surface corresponding to a near vision correction zone of predetermined refractive power, said outer annular surface corresponding to a distant vision correction



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zone of predetermined refractive power;

placing said diagnostic contact lens on the cornea of a patient's eye so that said posterior surface is in substantial contact with the cornea;

allowing said diagnostic contact lens to align itself with the cornea in a natural position while the patient looks at an effectively distant object;

upon aligning of said diagnostic contact lens in said natural position, disposing a series of test lenses before the patient's eye to determine a first aspheric power curve with which said central aspheric surface could be formed to provide optimal far vision for the patient under conditions of relatively high illumination and to further determine a power curve with which said outer annular surface could be formed to provide optimal distance vision under conditions of relatively low illumination; and

while the patient looks at an effectively near object, disposing another series of test lenses before the patient's eye to determine a power curve with which said second annular surface could be formed to provide optimal near vision for the patient under conditions of average reading illumination.

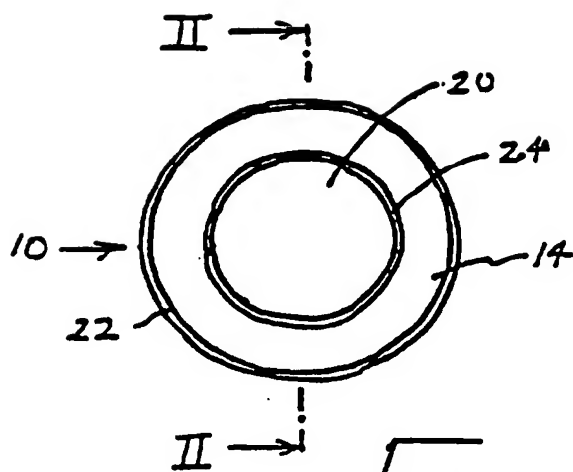


FIG. 1

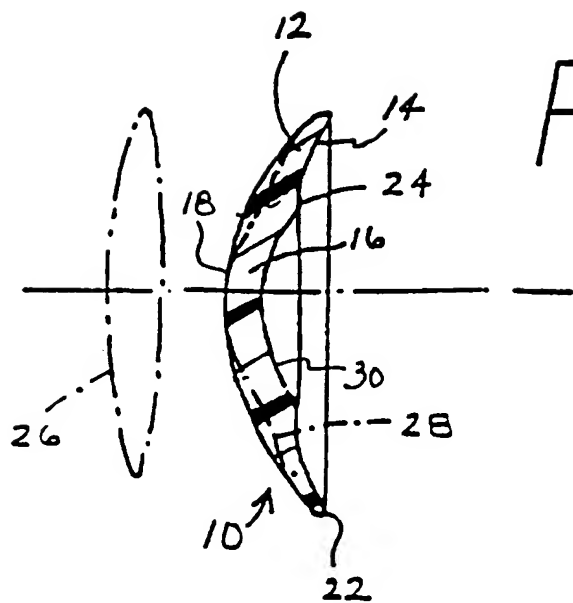
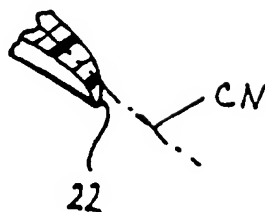
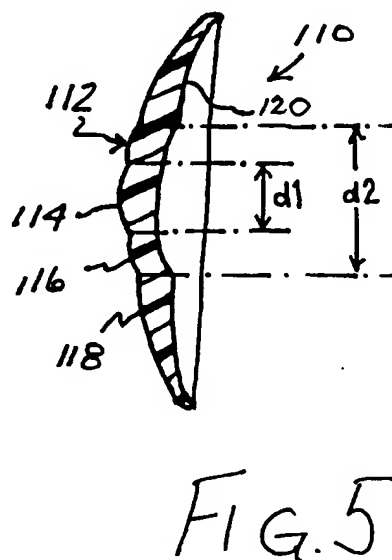
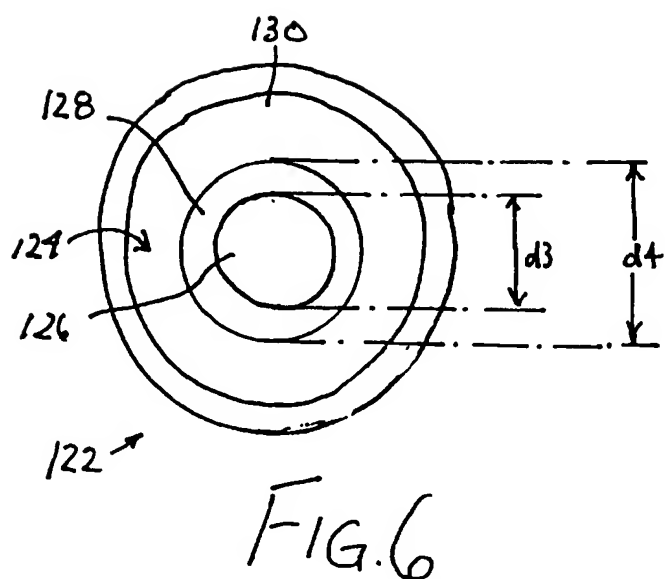
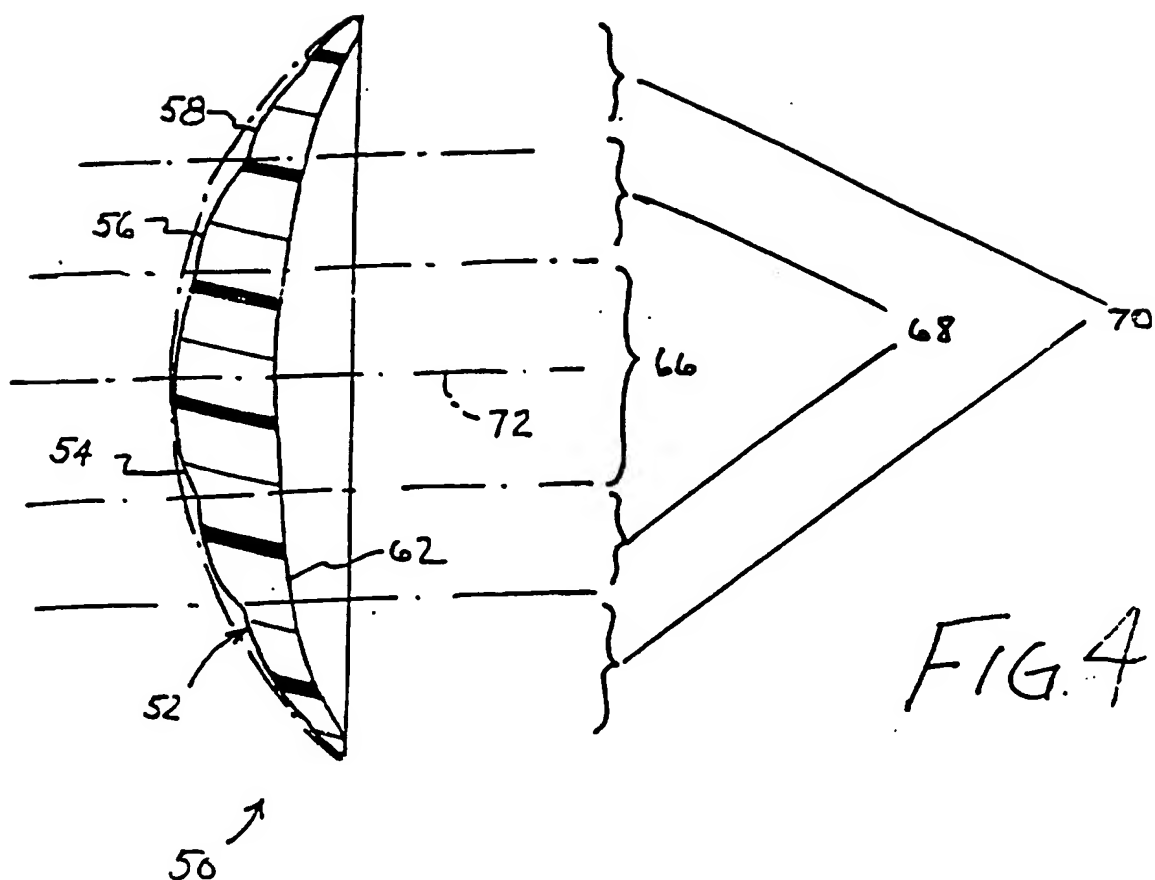
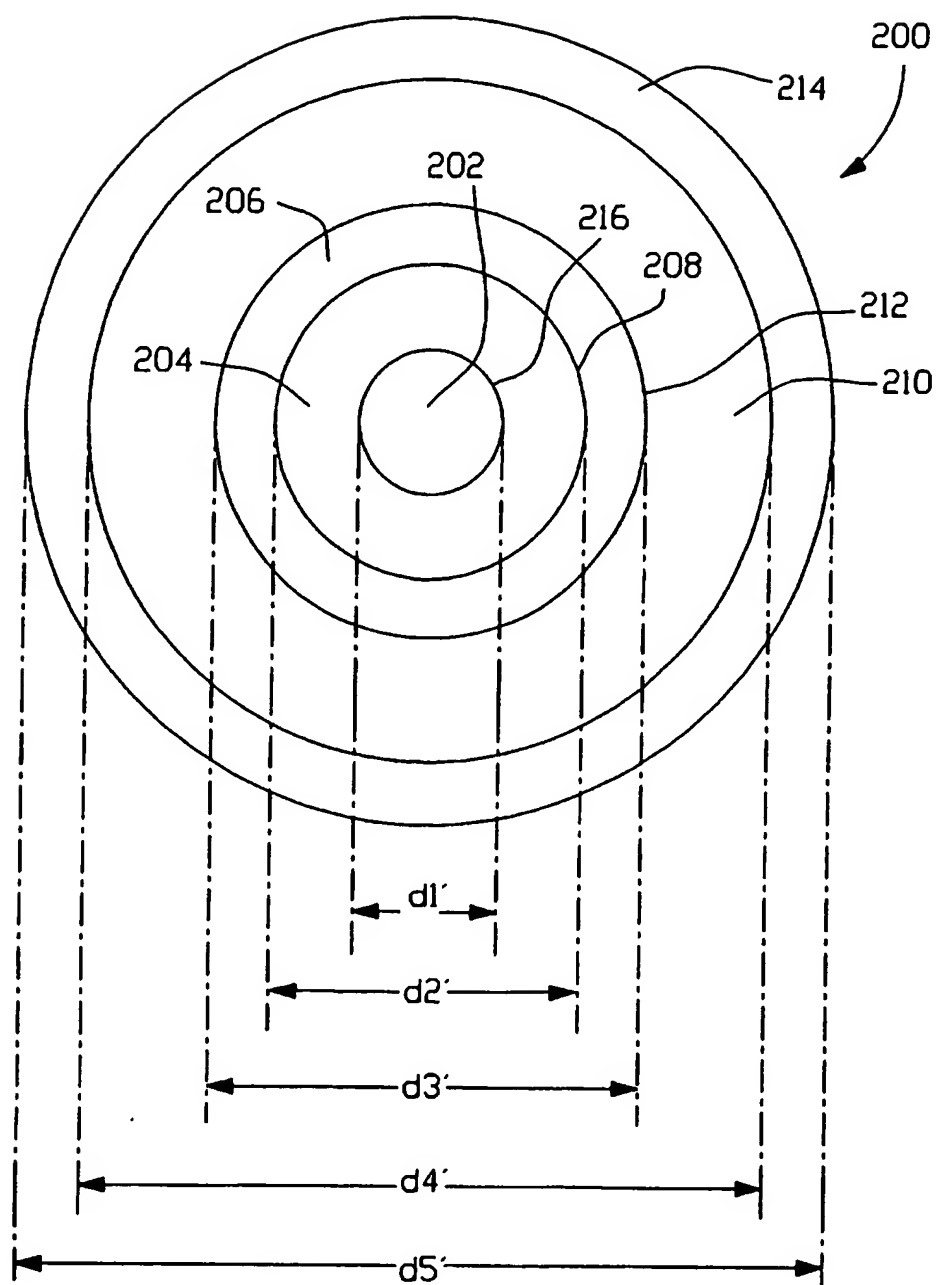


FIG. 2





**FIG. 7**

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US94/10498

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : G02C 7/04

US CL : 351/161, 177

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 351/160.R, 160.H, 161, 162, 177

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A         | US, A, 5,125,729 (MERCURE) 30 JUNE 1992  | 1-36                  |
| A         | US, A, 5,024,517 (SEIDNER) 18 JUNE 1991  | 1-36                  |
| A         | US, A, 5,002,382 (SEIDNER) 26 MARCH 1991   | 1-36                  |
| A         | US, A, 4,752,123 (BLAKER) 21 JUNE 1988   | 1-36                  |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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| * Special categories of cited documents: | * T | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  |
| * A                                      |     | document defining the general state of the art which is not considered to be of particular relevance   |
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Date of the actual completion of the international search

08 JANUARY 1995

Date of mailing of the international search report

12 JAN 1995

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